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CONTINUOUS PRODUCTION OF PREDACIOUS MITES IN THE GREENHOUSE

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Abstract.—The predacious mite species *Phytoseiulus persimilis* Athias-Henriot and *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae) were reared on potted red clover, *Trifolium pratense* L., in the greenhouse at ambient temperatures (min. 12°C). Twospotted spider mites, *Tetranychus urticae* Koch (Acari: Tetranychidae), were placed on the plants as prey. Red clover leaflets, on which were predators and prey, were removed and placed on potted alfalfa, *Medicago sativa* L., in the same greenhouse. One pot of red clover produced 5,000–8,000 predators per year, sufficient for satisfactory control of *T. urticae* on 50 pots of alfalfa. The technique requires minimal time, greenhouse space, and expense.

The purpose of this paper is to describe an unsophisticated technique for rearing predacious mites in a greenhouse used for arthropod research, with a minimum of time, space, and expense. The predators were used in routine biological control of twospotted spider mite, *Tetranychus urticae* Koch,[1,2] on potted alfalfa in the same greenhouse.

Many excellent methods for rearing predacious mites have been published: for example, Ristich 1956; McMurtry and Scriven 1965; Kamburov 1966; and Gilstrap 1977. However, these techniques are relatively sophisticated and are most suitable for biological control workers specializing in the study of predacious mites. Burnett (1970a, b, 1971, 1977) has examined in detail the population relationships between the predacious mite *Amblyseius fallacis* (Garman) and *T. urticae* on alfalfa in greenhouse and field.

The primary reason for rearing alfalfa in the greenhouse was as a host plant for the introduced pest, the alfalfa blotch leafminer, *Agromyza frontella* (Rondani).[3] (We reared 4 European parasite species on this host (Hendrickson and Barth 1979)). It was necessary to attempt biological control of *T. urticae* to avoid problems in insect rearing when alfalfa plants were treated with acaricides. Some common acaricides, at recommended dosages, were ineffective against *T. urticae*; others interfered with the rearing

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[1] Acari: Tetranychidae.

[2] Determined by R. L. Smiley, R. J. Gagné, or P. M. Marsh, Systematic Entomology Laboratory, USDA-SEA-AR, % U.S. National Museum, Washington, DC 20560.

[3] Diptera: Agromyzidae.

of *A. frontella*. For example, the effective acaricide oxythioquinox,[4,5] apparently rendered alfalfa partially repellant to *A. frontella* for 3–4 weeks. As a result, sprayed plants produced ca. 10% of the number of *A. frontella* that untreated controls produced.

We reared the predacious mites *Phytoseiulus persimilis* Athias-Henriot[6] and *Neoseiulus californicus* (McGregor)[6] together on the same plants as an experiment in competitive displacement. Although *P. persimilis* has a proven reputation for effectiveness in greenhouses, it may not be the best predator under all greenhouse conditions. Since little has been published on the biological characteristics of *N. californicus,* we had no way to estimate its relative competitive ability vis-à-vis *P. persimilis* in the greenhouse. Oatman et al. (1977) showed that *P. persimilis* was more effective than *N. californicus* (=*Amblyseius californicus*) in field releases against *T. urticae* on strawberries. If the 2 species have the same ecological niche in the greenhouse, competitive displacement should take place. On the other hand, both species of predators may coexist based on exploitation of slightly differing ecological niches, with a net effect in the control of *T. urticae* superior to that of either predator species alone. Although preliminary results indicate that *P. persimilis* has rapidly increased in numbers relative to *N. californicus,* the experiment is incomplete and is not discussed further in this paper.

Prey culture.—The *T. urticae* culture was maintained in the laboratory at 22–28°C. We could not rear prey mites in the same greenhouse with predators because of the danger of contamination. Prey mites were placed on 3–5 day old snap bean seedlings, of which we planted 200 per week. The bean plants were grown to the 5-leaf stage and cut when mite populations had become abundant. One-half of the mite-infested cut bean plants were used to infest snap bean seedlings, and mites on the other half were used as prey for predators.

Predator culture.—Predators were maintained in the greenhouse on potted red clover plants, *Trifolium pratense* L. Red clover is a vigorous grower in the greenhouse even at low winter temperatures, withstands severe populations of *T. urticae* and frequent removal of foliage, produces leaflets of convenient size for production of predators, and is not a productive host for greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood)[7].

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[4] Cyclic *S,S*-(6-methyl-2,3-quinoxalinediyl)dithiocarbonate.

[5] This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture nor does it imply registration under FIFRA as amended.

[6] Acari: Phytoseiidae. Determined by H. A. Denmark, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, FL 32602.

[7] Homoptera: Aleyrodidae.

Prey-infested snap bean plants were cut at the 5-leaf stage and placed on predator-infested red clover plants. Foliage from 5–6 snap bean plants were placed on a single red clover plant each week. Occasionally a red clover plant was excessively infested with *T. urticae,* necessitating a recuperative period of 1–2 weeks during which no mites were placed on it.

Prey- and predator-infested red clover leaflets were trimmed from plants and placed on target alfalfa plants for *T. urticae* control. The older red clover leaflets, usually the most severely damaged by *T. urticae* feeding, sustained the highest populations of predators and the lowest populations of prey. Therefore, these leaves were preferentially removed.

To determine the approximate rate of predator production, we selected 40 leaflets at random and counted mite populations on them under the microscope. The numbers of predators (*P. persimilis* and *N. californicus* combined) per leaflet were: adults, 2.6 $\bar{x}$, 3.0 s; immatures, 4.0 $\bar{x}$, 4.3 s; and eggs, 3.1 $\bar{x}$, 3.8 s. The number of *T. urticae* per leaflet were: adults, 7.3 $\bar{x}$, 7.1 s; immatures, 44.4 $\bar{x}$, 59.4 s; and eggs, 73.2 $\bar{x}$, 99.7 s. Based on a count of the number of leaflets regularly removed from each pot, we calculate annual predator production (all stages) at 5,000–8,000 per pot of red clover.

How predators were used in the greenhouse.—We placed a predator and prey-infested red clover leaf, comprised of 3 leaflets, on each of 80–160 pots of alfalfa, which were used in insect rearing programs and which were cut back weekly to ca. 5 cm height. Thus, the actual numbers of predators and prey placed on each pot of alfalfa were 3 times the averages listed above. Cut-back plants may have carried predators from earlier inoculations, which would enhance the effect of newly added predators.

Predators were placed on potted alfalfa only once in each 5–10 week usage cycle unless problems developed with pesticides applied for control of greenhouse whitefly. (Attempts to use the parasite *Encarsia formosa* Gahan[8] for *T. vaporariorum* control were unsuccessful because even parasitized immature whiteflies produced honeydew, which apparently rendered the plants unacceptable for oviposition by *A. frontella.*) We applied resmethrin[5,9] at 2–3 week intervals in the warm seasons of the year for greenhouse whitefly control. Applications of resmethrin appeared to kill nearly all adult and immature predacious mites, but left predator eggs alive. Twospotted spider mites were unaffected by the pesticide, so that spotty outbreaks resulted. To prevent pesticide-induced upsets of *T. urticae,* we placed a single predator- and prey-infested red clover leaflet on each pot of

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[8] Hymenoptera: Aphelinidae. Kindly provided by M. J. Tauber, Dept. Entomology, Cornell Univ., Ithaca, NY.

[9] [5-phenylmethyl)-3-furanyl]methyl *cis-trans-(±)*-2,2-dimethyl-3-(2-methyl-1-propenyl)cyclopropanecarboxylate.

alfalfa after the period of residual activity of resmethrin (3 days in warm seasons).

One pot of red clover provided enough predators for 50 pots of alfalfa. In general, the predacious mites gave us good control of *T. urticae,* better than previously attained with acaricides. The bench area required for 16 red clover plants in the greenhouse was 1.5 m^2.

On about one pot of alfalfa in 100, we observed *T. urticae* feeding damage on the first 15 cm of alfalfa regrowth, but at about this height, the predators built up sufficiently high populations so that the remaining alfalfa growth had no or very slight mite damage. Potted alfalfa used in rearing the alfalfa blotch leafminer was 35–50 cm in height, and mite damage on the bottom 15 cm was unimportant.

We estimated that 1½ h per week were required in this technique for successful biological control of *T. urticae* on 800 alfalfa plants. The time estimate includes planting beans, watering, movement of prey on bean leaves to red clover plants, and movement of prey and predators on red clover leaflets to alfalfa plants. The time spent was ca. 3 times that formerly required for the application of miticides, but was not excessive.

Discussion

The technique is useful for biological control of *T. urticae* in small greenhouses (ours is 100 m^2). Its simplicity lends itself to routine application; it requires relatively little time, and only enough greenhouse bench space for one pot with predators per 50 pots with target prey; and it avoids complicating factors in research induced by acaricide applications.

The technique may have applicability in commercial greenhouses, since it is analogous to Gould et al. (1969) description of a 'banker' plant as a source for predacious mites in greenhouses used for cucumber production. In their concept, *T. urticae* on one cucumber plant in 100 was allowed to reach heavy population levels, then *P. persimilis* was added. As many as 5,000 predators were produced on a single cucumber plant for the remainder of the greenhouse. In the technique described in the present paper, prey and predators were introduced simultaneously on red clover 'banker' plants, with frequent addition of prey mites. The number of predacious mites produced (all stages), counted at the time of removal, was 5,000–8,000 per pot per year.

Other predators of *T. urticae* encountered in the greenhouse were *Anystis agilis* (Banks)[2,10] and *Feltiella carolina* (Felt),[2,11] but both species were un-

[10] Acari: Anystidae.

[11] Diptera: Cecidomyiidae.

common and contributed little to control of *T. urticae*. Larvae of *F. carolina* fed on eggs and immotile forms of *T. urticae*. (A single individual of the parasite *Aphanogmus* sp.[2,12] emerged from a puparium of *F. carolina*.)

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[12] Hymenoptera: Ceraphronidae.